In situ snow and vegetation properties along a latitudinal transect in North-Eastern Canada: A reference dataset to assess satellite SWE products

Ludovic Brucker[1,2], Alex Langlois[3], Alain Royer[3], Laurent Arnaud[4], Patrick Cliche[3], Kalifa Goita[3], Ghislain Picard[4], Alex Roy[3], Chris Derksen[5]

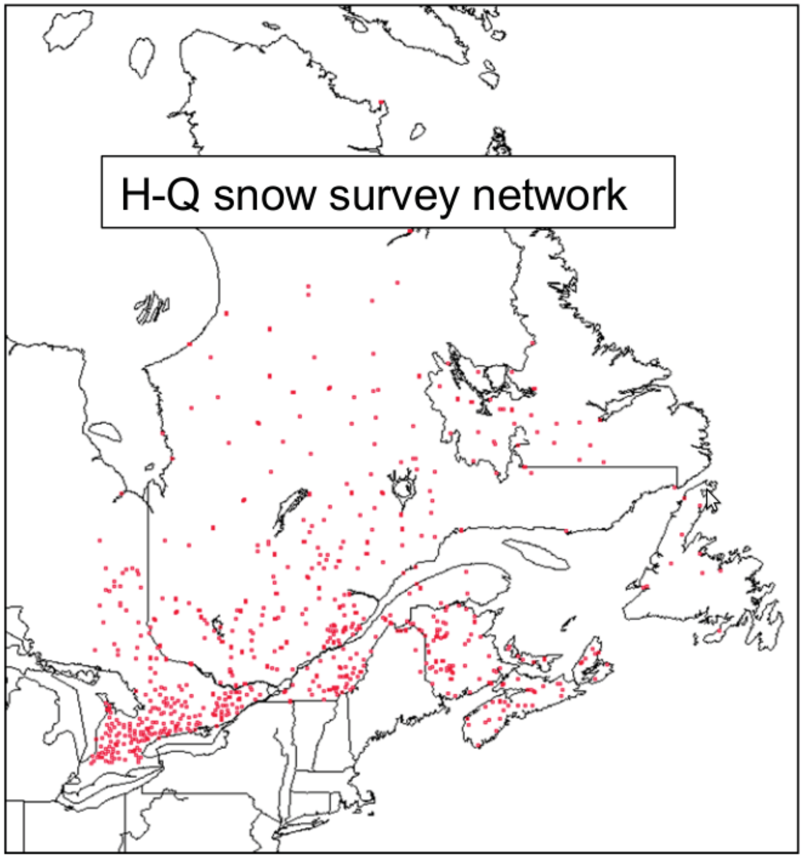
[1] NASA GSFC Cryospheric Sciences Lab., code 615, Greenbelt MD, USA
[2] Universities Space Research Association – GESTAR, Columbia, MD, USA
[3] Uni. Sherbrooke, CARTEL, Québec, Canada
[4] Uni. Grenoble Alpes/CNRS, LGGE, Grenoble, France
[5] Environment Canada, Climate Research Division, Toronto, Canada

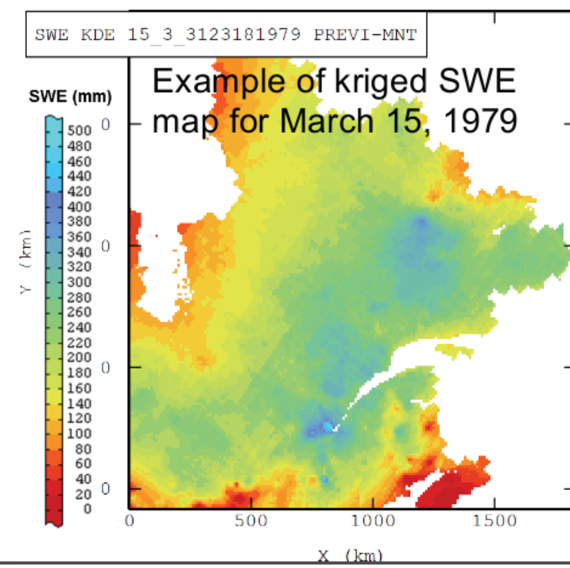
Slide courtesy of Ross Brown (presented yesterday morning)

Now that you mention it, Québec is a potentially data-rich SnowPEx validation region! **Hydro-Quebec have expressed willingness to contribute data to SnowPEx**

What Quebec Offers:

- N-S gradient covering main NH land cover classes (agric, mixed hardwood, taiga, tundra)
- Snow survey data from several hundred sites for 40+ years
- 10 km kriged SWE dataset with topography as external drift variable covering 1970-2013 period
- GMON SWE obs at 7 stations
- IPY snow transect (Langlois et al)

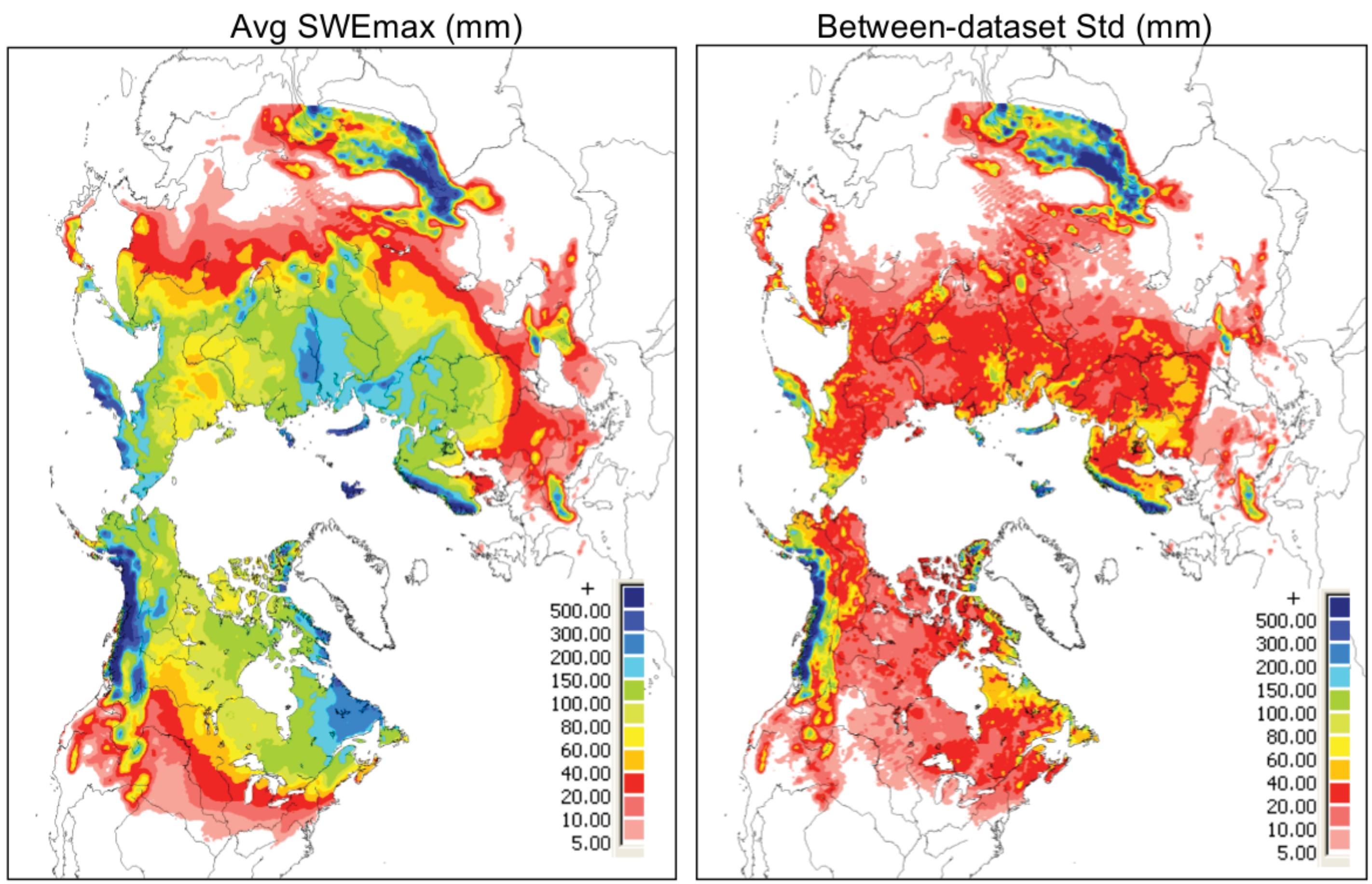




Environment Canada Environnement Canada

Slide courtesy of Ross Brown (presented yesterday morning)

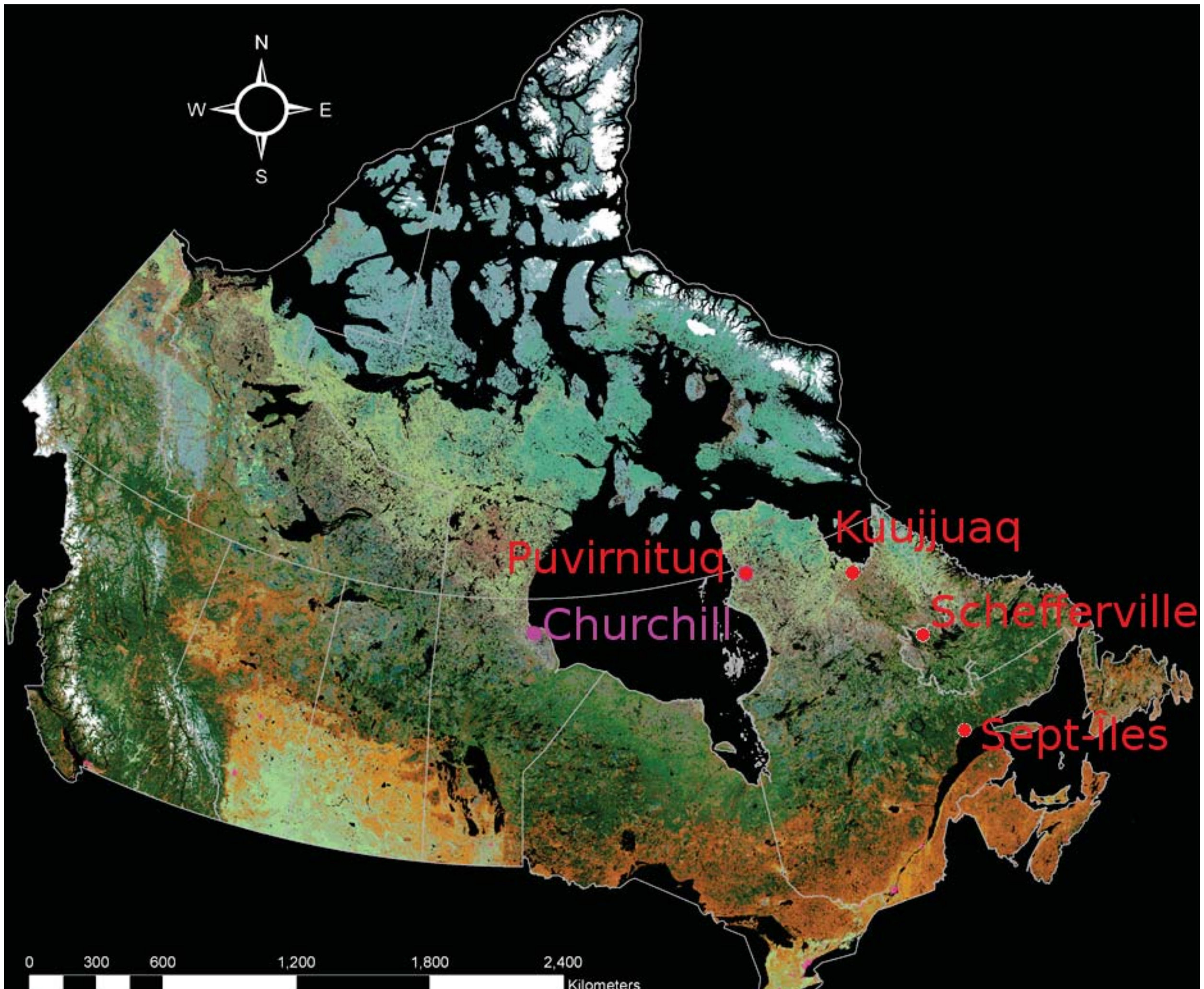
Do uncertainties in observations provide any guidance of where SnowPEx should concentrate evaluation activities? i.e.focus on regions where current products are not doing well



Between dataset variability in mean annual maximum monthly SWE, 1999-2009 (GlobSnow, L&H, MERRA, CMC, ERA-interim) Minimum of 3 datasets to compute stats. NH land area north of 30°N

Description

The transect took place in 2008 (IPY), within the EC-led project:
Variability and Change in the Canadian Cryosphere:
A contribution to State and Fate of the Cryosphere



Transect of 2000 km
Sampled every ∼40 km
Four nodes

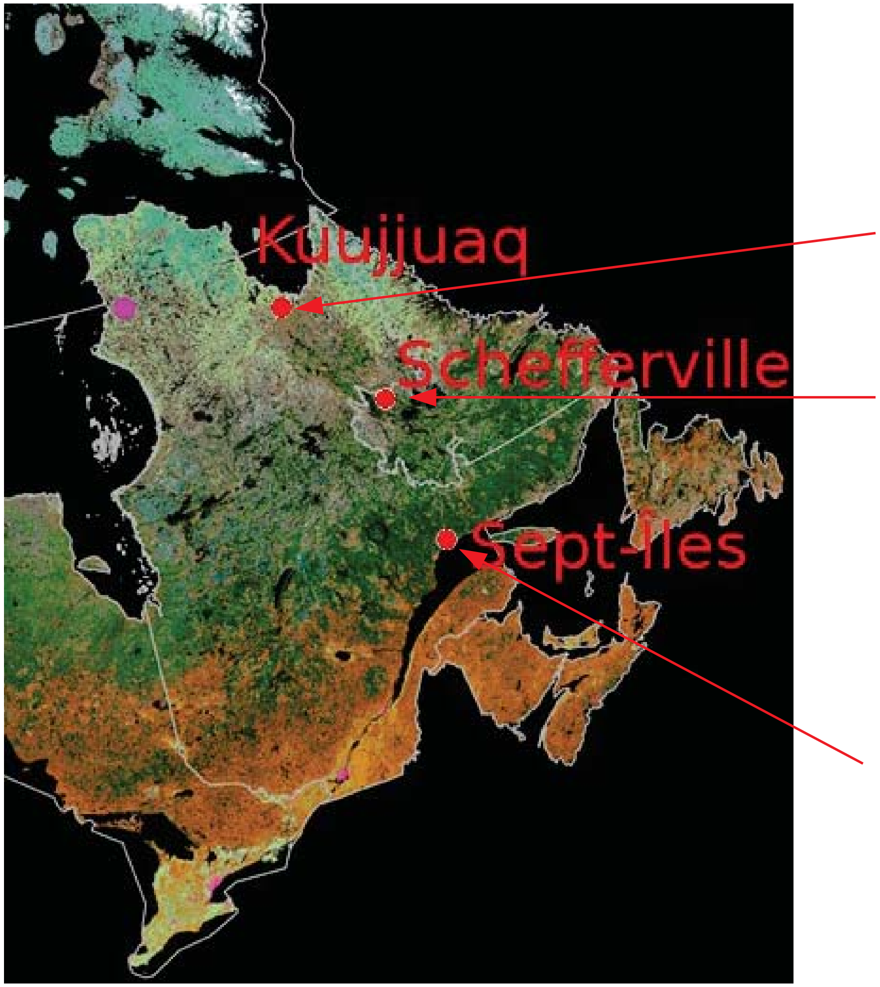
As latitude increases:
vegetation ↘
and SWE ↘

Description

- The campaign lasted 2 weeks (February 16–29, 2008)
  included 4 teams of 4 people

- Every team has the same protocol and the same material

Description

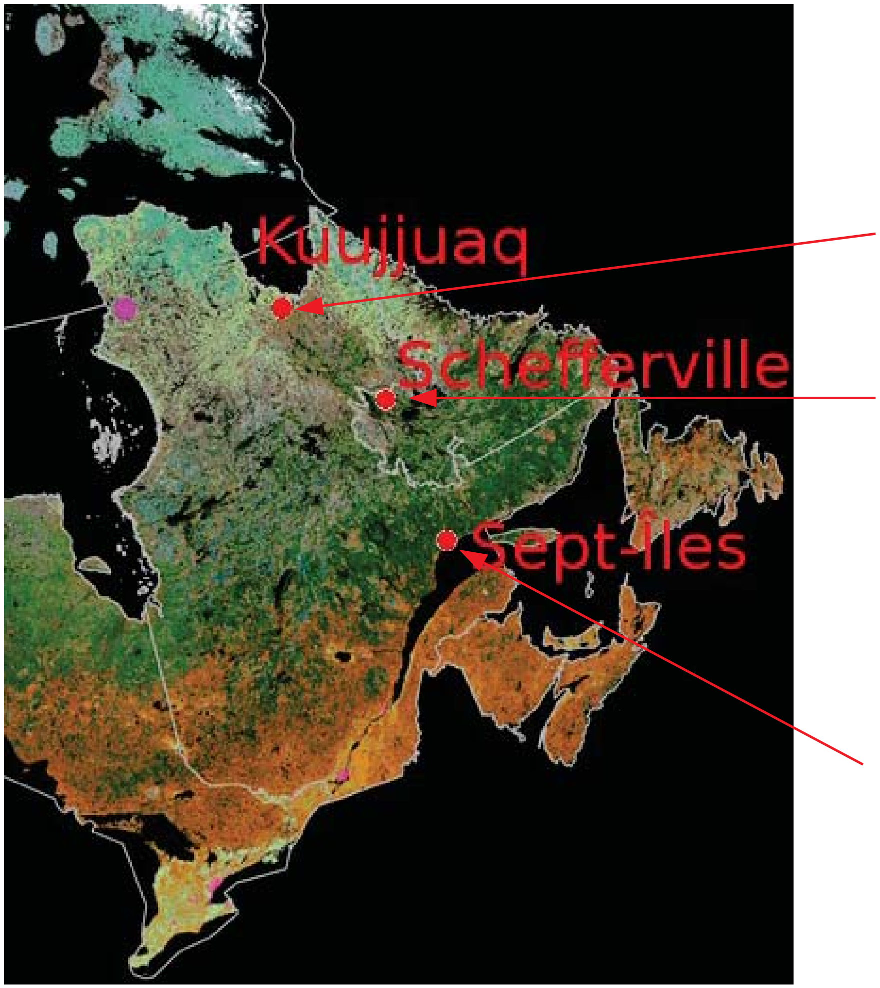


Tundra

Taiga

Boreal forest

Description



Tundra
SWE 110±50 mm

Taiga
SWE 200±75 mm

Boreal forest
SWE 400±120 mm

Properties measured

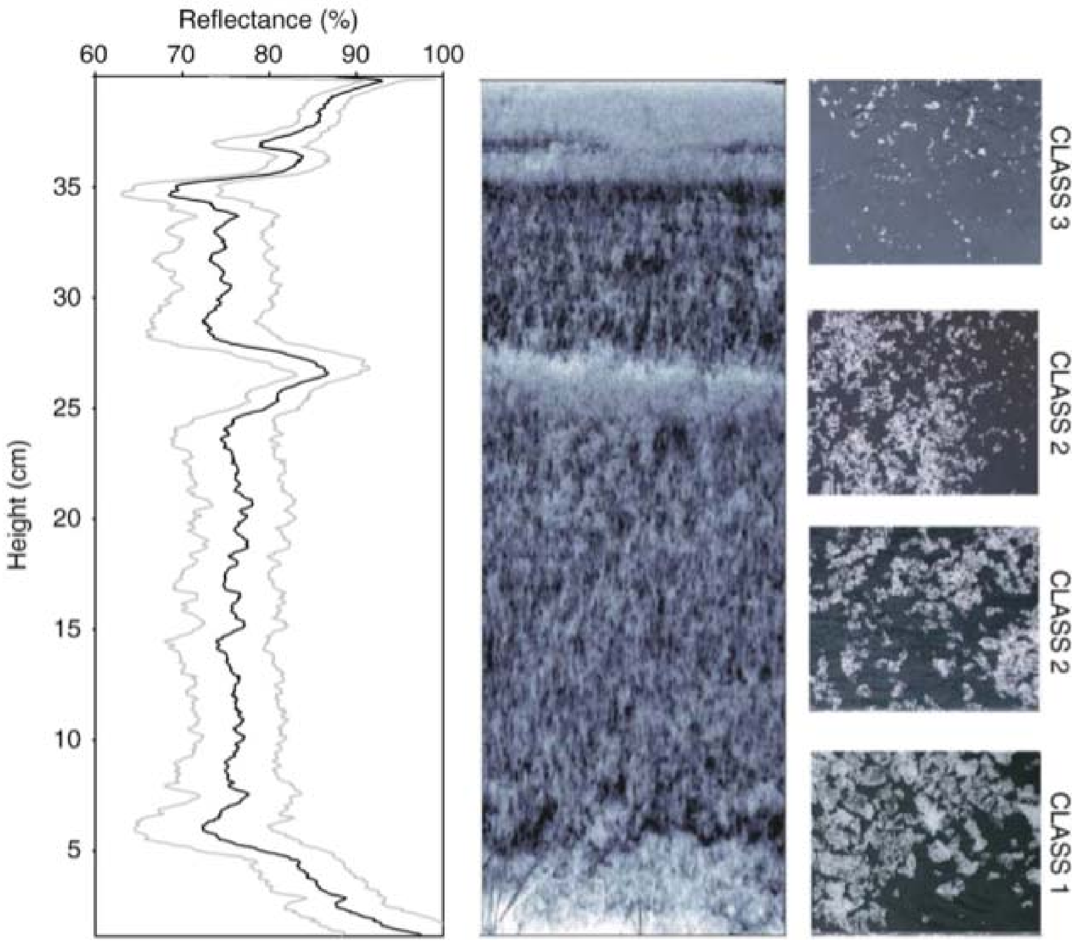
Measured **snow properties**

- stratigraphy
- grain size (picture with grid)
- density
- temperature
- near infrared reflectance
- “hardness”– snow micropen (in Schefferville only)
- thermal conductivity (in Kuujjuaq only)

Properties measured

Measured **snow properties**

- stratigraphy
- grain size (picture with grid)
- density
- temperature
- near infrared reflectance
- "hardness"– snow micropen (in Schefferville only)
- thermal conductivity (in Kuujjuaq only)



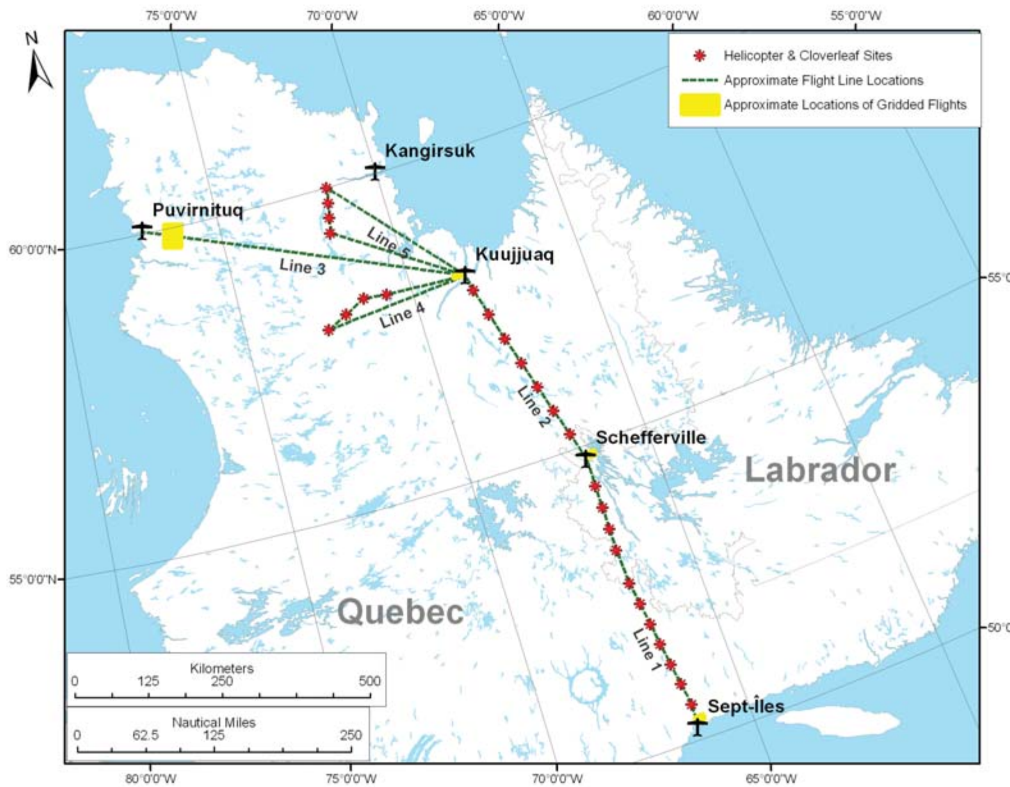
Properties measured

Measured **snow properties**

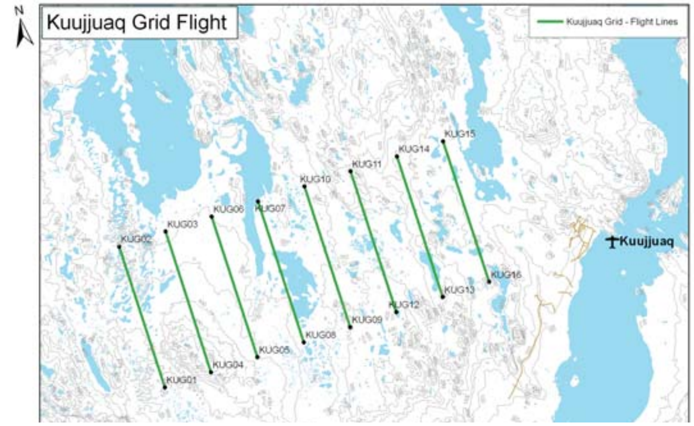
- stratigraphy
- grain size (picture with grid)
- density
- temperature
- near infrared reflectance
- “hardness”– snow micropen (in Schefferville only)
- thermal conductivity (in Kuujjuaq only)

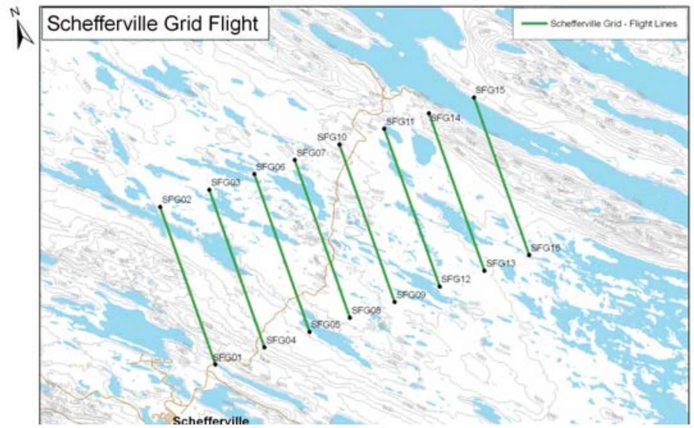
Measured **vegetation properties**

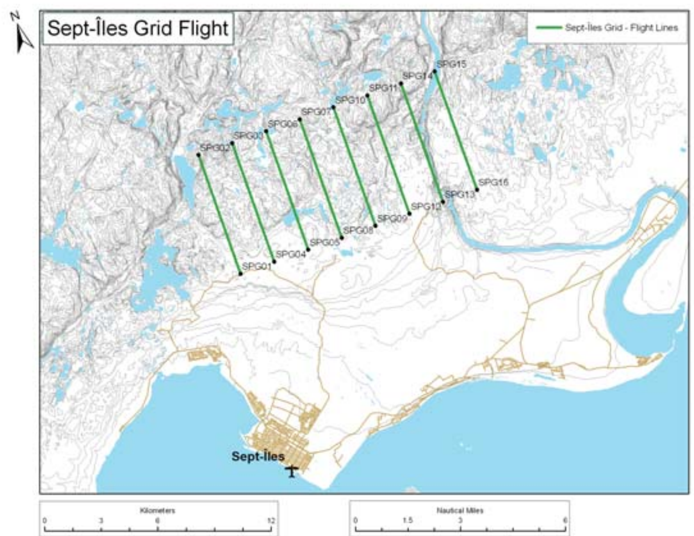
- Density
- Species
- Tree diameter
- Height



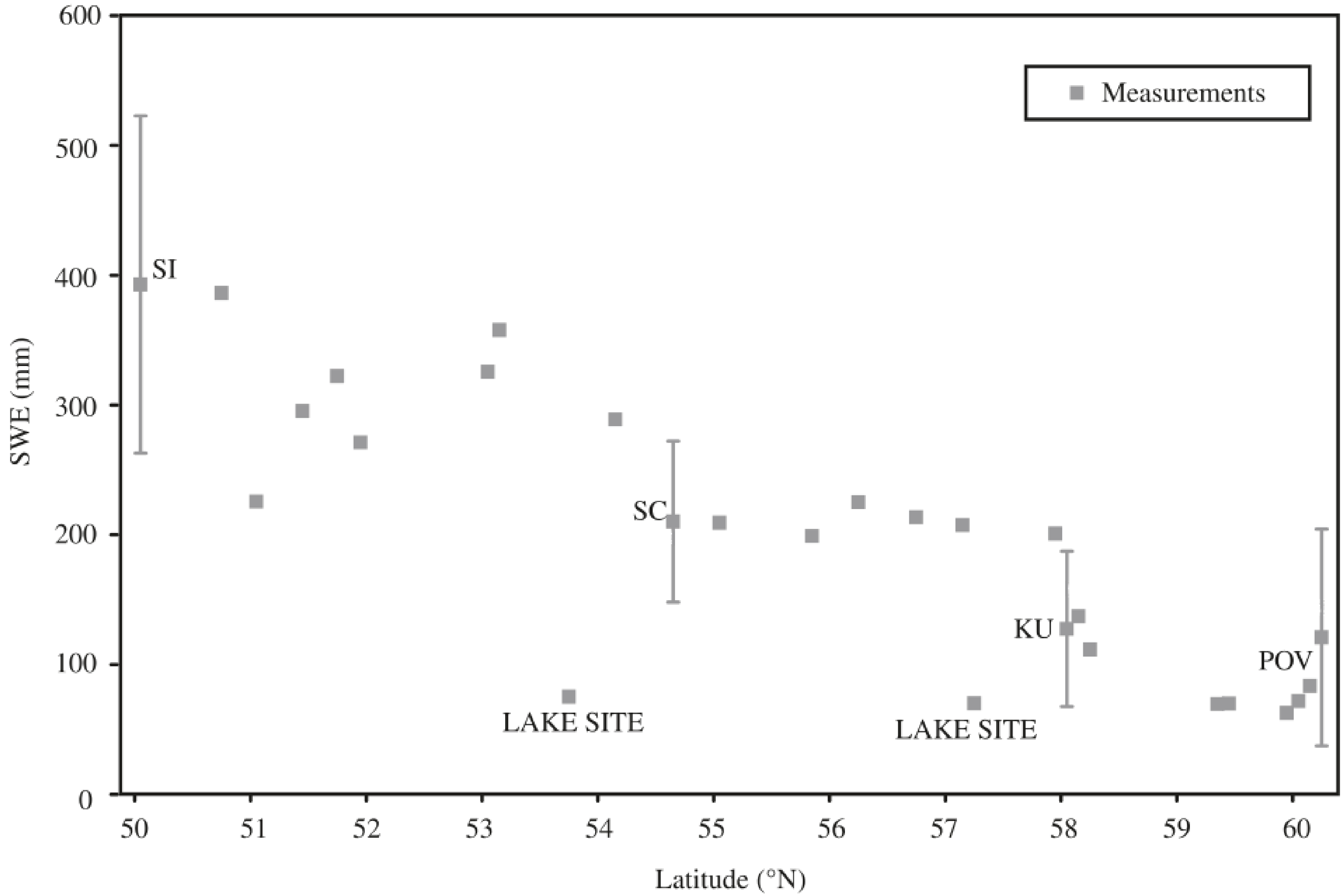
Sites/Lines	Dominant Land Cover	Number of sampling sites
Sept-Îles (SI)	Dense boreal forest	57
Sept-Îles to Schefferville (HL1 and HL2)	Boreal forest to taïga transition	10
Schefferville (SC)	Taïga	38
Schefferville to Kuujjuaq (HL3)	Taïga to tundra transition	7
Kuujjuaq (KU)	Open taïga and tundra	31
Kuujjuaq to Kangirsuk (HL4 and HL5)	Open tundra	8



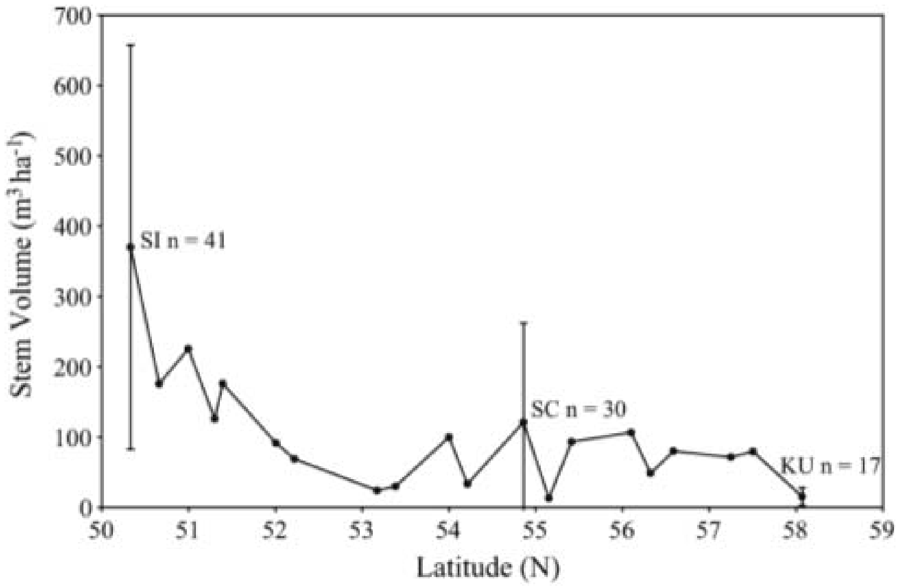


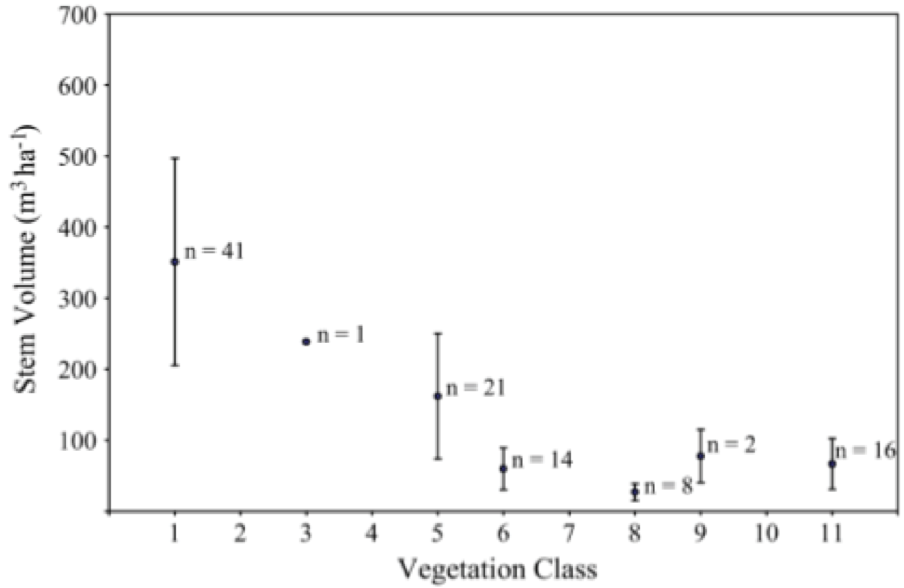


Latitudinal evolution of SWE



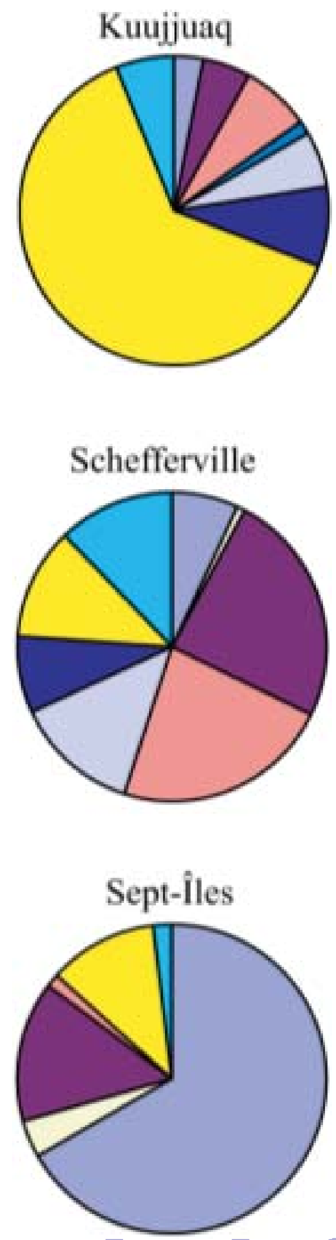
Latitudinal evolution of the vegetation





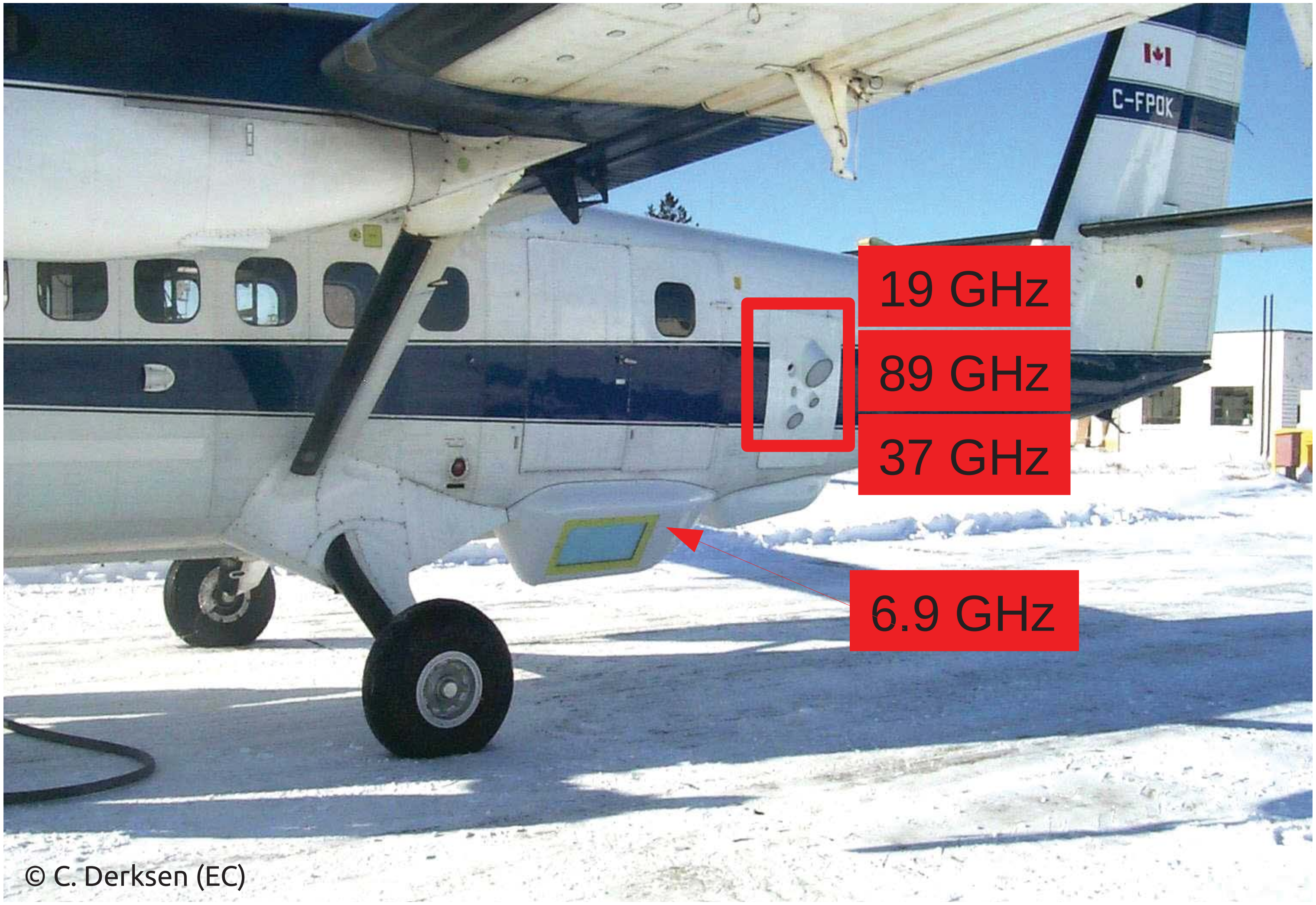
Latitudinal evolution of the vegetation

Class ID	Description
1	Needleaved dominant with > 60% spatial coverage > 75%
2	Broadleaf dominant with > 60% spatial coverage > 75%
3	Mixed with > 60% spatial coverage > 75% and Needleaved dominant with > 50% spatial coverage > 75%
4	Mixed with > 60% spatial coverage > 75% and Broadleaf dominant with > 25% spatial coverage > 50%
5	Needleaved dominant with > 40% spatial coverage > 60%
6	Needleaved dominant with > 25% spatial coverage > 40%
7	Broadleaf dominant with > 25% spatial coverage > 60%
8	Mixed with > 25% spatial coverage > 60% and Needleaved dominant with > 50% spatial coverage > 75%
9	Mixed with > 25% spatial coverage > 60% and Broadleaf dominant with > 25% spatial coverage > 50%
10	Burnt
11	Bare soil, non forested areas
12	Water



Airborne passive microwave observations

EC Twin Otter and with the radiometers



Conclusion

Rare in-situ data set with extensive **ground** and **airborne** data

Includes a latitudinal variability of snow properties (including SWE)
vegetation characteristics

$\sim$150 snowpits in different snow and vegetation classes

Data set relevant to assess existing and future SWE algorithms/products

(Analyzing the influence of lakes is also possible...)

* Langlois, A., L. Brucker, J. Kohn, A. Royer, C. Derksen, P. Cliche, G. Picard, M. Fily, and J.-M. Willemet (2009), Regional retrieval of snow water equivalent (SWE) using thermodynamic snow models in Quebec, Canada, J. Hydrometeorol., 10(6), 1447-1463.

* Langlois, A., A. Royer, and K. Goita (2010a), Linkages between simulated and spaceborne passive microwave brightness temperatures with in-situ measurements of snow and vegetation properties, Can. IPY Spec. Issue Can. J. Remote Sens., 36(1), 135-148.

* Langlois, A., A. Royer, B. Montpetit, G. Picard, L. Brucker, L. Arnaud, K. Goita and M. Fily (2010b), On the relationship between measured, and modeled snow grain morphology using infrared reflectance, Cold Reg. Sci. Technol., 61, 34-42.

* Derksen, C., P. Toose, A. Rees, L. Wang, M. English, A. Walker, M. Sturm (2010), Development of a tundra-specific snow water equivalent retrieval algorithm for satellite passive microwave data, Remote Sensing of Environment, 114(8), 1699-1709

* Langlois, A., A. Royer, F. Dupont, A. Roy, K. Goita and G. Picard (2011), Improved vegetation corrections for satellite passive microwave remote sensing using airborne radiometer data, IEEE Trans. Geosci. Remote Sens., 49(10), 3824-3837.

* Langlois, A., A. Royer, C. Derksen, B. Montpetit, F. Dupont, and K. Goita (2012), Coupling the snow thermodynamic model SNOWPACK with the microwave emission model of layered snowpacks for subarctic and arctic snow water equivalent retrievals, Water Resour. Res., 48, W12524.

* Forman, B.A., Reichle, R.H., Derksen, C. (2014), Estimating Passive Microwave Brightness Temperature Over Snow-Covered Land in North America Using a Land Surface Model and an Artificial Neural Network, IEEE Trans. Geosci. Remote Sens., vol.52, no.1, pp.235-248.